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ABSTRACT

Two experiments were conducted to explore infant responsiveness to color and temperature novelty under bimodal conditions. In experiment 1, a total of 48 infants of 26-31 weeks were familiarized with a warm-red, warm-blue, cool-red, or cool-blue object, and assigned to one of three experimental groups. Each group was stimulated by a novel test object that differed from others in visual qualities, tactual qualities, or visual and tactual qualities. Findings were inconclusive in regard to whether infants processed information about colors and temperatures of objects they explored. Experiment 2 explored ways in which infants responded when presented with an object that was a novel compound of previously experienced colors and temperature. A total of 18 children between 27 and 30 weeks of age participated in a procedure in which each infant received two familiarization trials with an object of a different color and temperature in each trial. In two test trials, experimental subjects were first exposed to a novel compound of stimulus characteristics presented during familiarization and then to a representation of a familiarization object. For control subjects, the order was reversed. No evidence was found for infant memory of visually and haptically specific object features following bimodal exploration. (RH)

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Bimodal perception of color and temperature in six-month-old infants.

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Bimodal perception of color and temperature in six-month-old infants.

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When infants of around six to seven months of age are presented with a graspable object within reach they usually initiate a predictable pattern of exploration involving grasping, holding, looking and intermittent mouthing. While this activity would appear to be directed at obtaining information about the visual and tactual qualities of the object, "it is not necessarily the case that both the visual and haptic consequences of the exploration are registered" (Rolfe-Zikman, 1987). The presence of visual and haptic, i.e. bimodal exploration does not in itself indicate what parts of the multimodal stimulus package infants attend to during this activity.

It is possible to determine whether haptic and/or visual information is attended during bimodal exploration by using haptically-specific and/or visually-specific object features. E.g. if infants demonstrate recognition memory for the weight of an object following bimodal experience then attention to haptic information could be inferred. Similarly, if recognition memory for color obtains then attention to visual information would be established.

Research using this approach has recently begun and is generating some surprising results. E.g. Bushnell, Shaw and Strauss (1985) familiarised six-month-old infants bimodally with an object of a particular temperature - warm or cool -

and color - red or blue - and in the test phase presented them with an object of a novel color only or a novel temperature only. Significantly more visual and haptic interest in the test object of a novel temperature indicated that infants had attended to the tactual coonsequences of their manipulation. However differential responsiveness to novelty was not observed in the color-change group. Bushnell et al interpreted this as possibly indicating "tactual capture", with infant interest in the tactual characteristics of an object "diluting" attention to the visual properties. Failure to achieve recognition memory for object characteristics which could be expected to be readily discriminable under unimodal visual conditions was also a feature of a series of experiments by Rolfe reported elsewhere (Rolfe-Zikman, 1987).

The two experiments to be reported today were designed to explore further infant responsiveness to color and temperature novelty under bimodal conditions, including whether infants form compounds of the two features when they are part of a single object that is explored.

Experiment 1

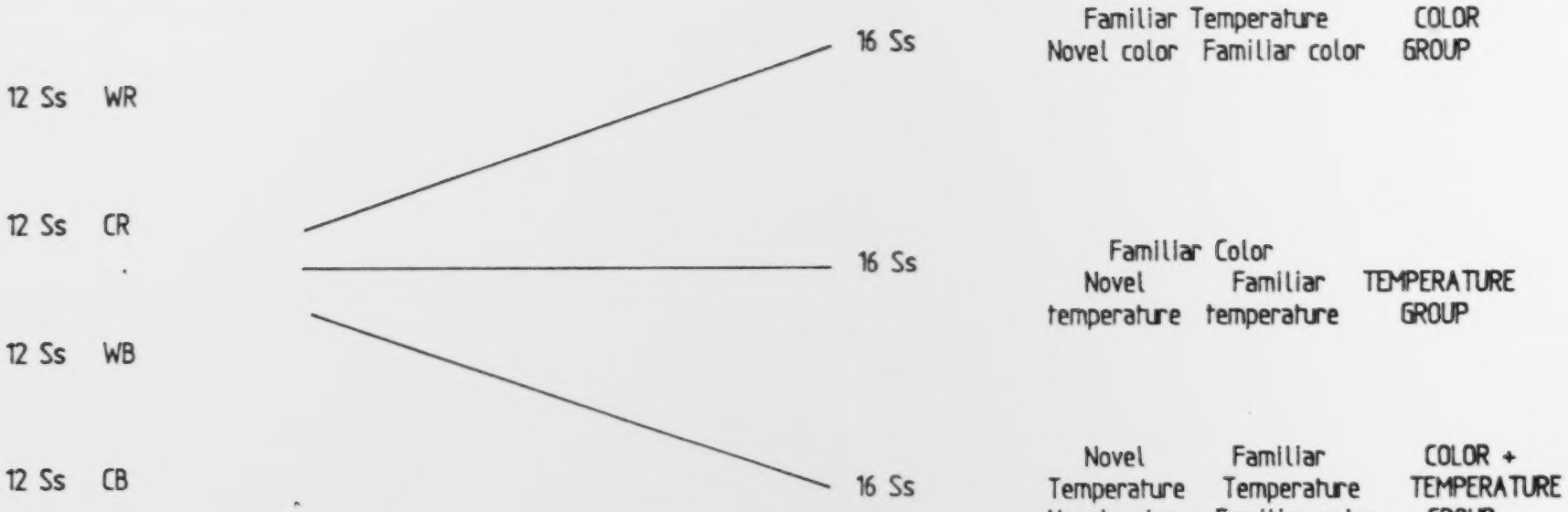
Forty-eight healthy full term infants aged between 26 and 31 weeks participated in Experiment 1 which was designed to repeat the work of Bushnell et al (1985) referred to earlier. The design of this experiment is shown in Figure 1.

O/H 1 Figure 1 Design of Study 1

All infants were familiarised bimodally with a single object - a small plastic centrifuge tube with a screw on lid. Each

FAMILIARISATION PHASE

TEST PHASE



WR - Warm Red
CR - Cool Red
WB - Warm Blue
CB - Cool Blue

figure 1 - THE DESIGN OF STUDY 1

tube was covered with red or blue contact paper and could be filled with hot or cold water so that a warm or cool surface temperature was achieved. Infants were familiarised with either a warm-red (WR),warm-blue (WB), cool-red (CR) or cool-blue (CB) object and then were assigned by sex to one of three experimental groups.

For the first group, designated the Color group, the novel test object differed from the familiar object only in its visual qualities i.e. it was the same temperature as the familiar object but of a novel color. For the second group, designated the Temperature group, the novel test object differed from the familiar object only in its tactual qualities i.e. it was the same color as the familiar object but of a novel temperature. Infants in the third group, designated the Color & Temperature group received an object which was novel in both its visual and tactual qualities - a new color and temperature.

The order of test trials, novel or familiar, was counterbalanced for each group. Each trial continued until the infant "broke" with the stimulus i.e. neither looked at nor touched the stimulus for two seconds - or after three minutes had elapsed, as had been the case in the experiment of Bushnell et al .

All infants were tested at the Institute of Early Childhood Development (IECD) infant laboratory. During sessions they sat in a high chair with an attached tray onto which the objects were placed. The attending caretaker was present at all times and infant behaviour was videotaped for later scoring and analysis. Detailed analyses of these

videotapes have not yet been completed and it is intended to record a number of dependent variables from them. For todays presentation, however, data to be presented is based on duration of fixation and total duration of manipulation only.

The results of the experiment are shown in Table 1.

O/H 2 Table 1 Experiment 1 data.

From Table 1, it can be seen that during familiarisation infants on average were in contact with the object for over two minutes and it was quite common for infants to hold the object for the full three minutes. Total looking times during familiarisation were shorter and more looking was observed earlier than later in the trial. Nonetheless, on average infants spent over one minute looking at the familiarisation object. For whatever reasons, then, the infants tested found the objects of considerable interest, a conclusion which is supported by the fact that only two subjects were rejected - one for fussiness and one due to failure to touch the objects.

Visual fixation and manipulation during the familiarisation trial were each analysed using a 3 (Group) x 2 (Color of familiarisation object) ANOVA to determine whether groups differed initially in levels of visual and haptic interest and whether either color or temperature was spontaneously preferred. There were no significant outcomes from these analyses for any of the dependent variables, so for the purposes of later analyses data were combined across the two colors and temperatures.

Table 1. STUDY 1 - DATA

	Color group			Temperature group			Color & Temperature group		
	Familiarization trial	Test trial N	Test trial F	Familiarization	Test trial N	Test trial F	Familiarization	Test trial N	Test trial F
Mean duration fixation (secs)	65.96	47.69	35.59	72.54	56.8	47.2	68.77	52.74	40.66
SD	28.59	31.71	22.04	35.39	33.6	32.04	26.19	34.00	35.87
Mean duration first fixation (secs)	6.49	4.1	3.66	9.19	6.87	3.73	6.51	6.81	4.31
SD	4.29	2.3	2.18	6.05	8.89	2.27	6.11	4.87	2.85
Mean duration manipulation (secs)	154.12	102.4	89.6	131.93	116.36	104.3	144.26	110.09	78.52
SD	37.08	57.36	60.8	47.69	63.58	59.5	54.58	64.75	68.32

Preliminary analyses of test trial data for each group using pair-wise correlated t-tests (2-tailed) were conducted first. These compared the time spent looking at the novel and familiar objects, and the time spent manipulating the novel and familiar objects and they failed to reach significance in any group. This result was unexpected, especially for the Temperature and Temperature & Color groups and indicated that infants did not respond with increased interest to a new color or new temperature. There are at least three possible explanations of this finding. Firstly, infants may not have attended to the color or temperature of the familiarisation objects, or secondly may not have remembered them across trials. A third possibility is that infants had attended and remembered one or both features but that this was not evident in the analyses conducted thus far or perhaps in the dependent variables selected.

In an attempt to examine some of these possibilities, the test trial data were analysed further by a 3 (Groups) x 2 (Test trial order - novel first vs novel second) x 2 (Trials - novel vs familiar) ANOVA with repeated measures on the last factor.

For each dependent variable, the effect of Trials was significant, $F(1,42) = 5.12$, $p=.029$ (duration of first fixation); $F(1,42) = 4.58$, $p=.038$ (total duration of fixation); $F(1,42) = 5.15$, $p=.028$ (total duration of manipulation) and this did not interact significantly with the Group factor. Infants overall, then, attended more to the novel test object than the familiar test object in their initial visual responses and their visual and haptic behaviour over the total trials. However for total duration of fixation

and manipulation this increased attention to novelty was dependent upon the order of test trials. For both variables there was a significant interaction between Trials and the Order of test trials factor, F (1,42) = 9.62, p=.003 and F (1,42) = 10.02, p=.003. The nature of this interaction for visual fixation data is indicated in Figure 2 and for manipulation data in Figure 3.

O/H 3 Figure 2 Ordtt x Trials interaction - visual fixation.

O/H 4 Figure 3 Ordtt x Trials interaction - manipulation.

We have yet to complete a number of post-hoc analyses of these interactions. However, the results of a 2 (Group) x 2 (Trials - novel vs familiar) ANOVA with repeated measures on the second factor conducted separately for each of the Order of test trials indicated that the difference between the two trials was highly significant when the novel object was presented first, F (1,21) = 10.92, p=.003 (for fixation duration); F (1,21) = 11.83, p=.002 (for manipulation duration) but not when the novel object was presented on the second test trial F (1,21) = .62, p=.438 (for visual fixation) and F (1,21) = .53, p=.475 (for manipulation). There were no significant interactions between the Group and Trials factors.

Bushnell et al (1995) obtained a similar result for their manipulation data and among other things, explored this by comparing response to the novel and familiar objects on the first test trial only. We intend to analyse our data in a similar way to determine which groups, if any, show more

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Figure 2. STUDY 1 - ORDER OF TEST TRIALS x TRIALS (N vs F) INTERACTION
VISUAL FIXATION

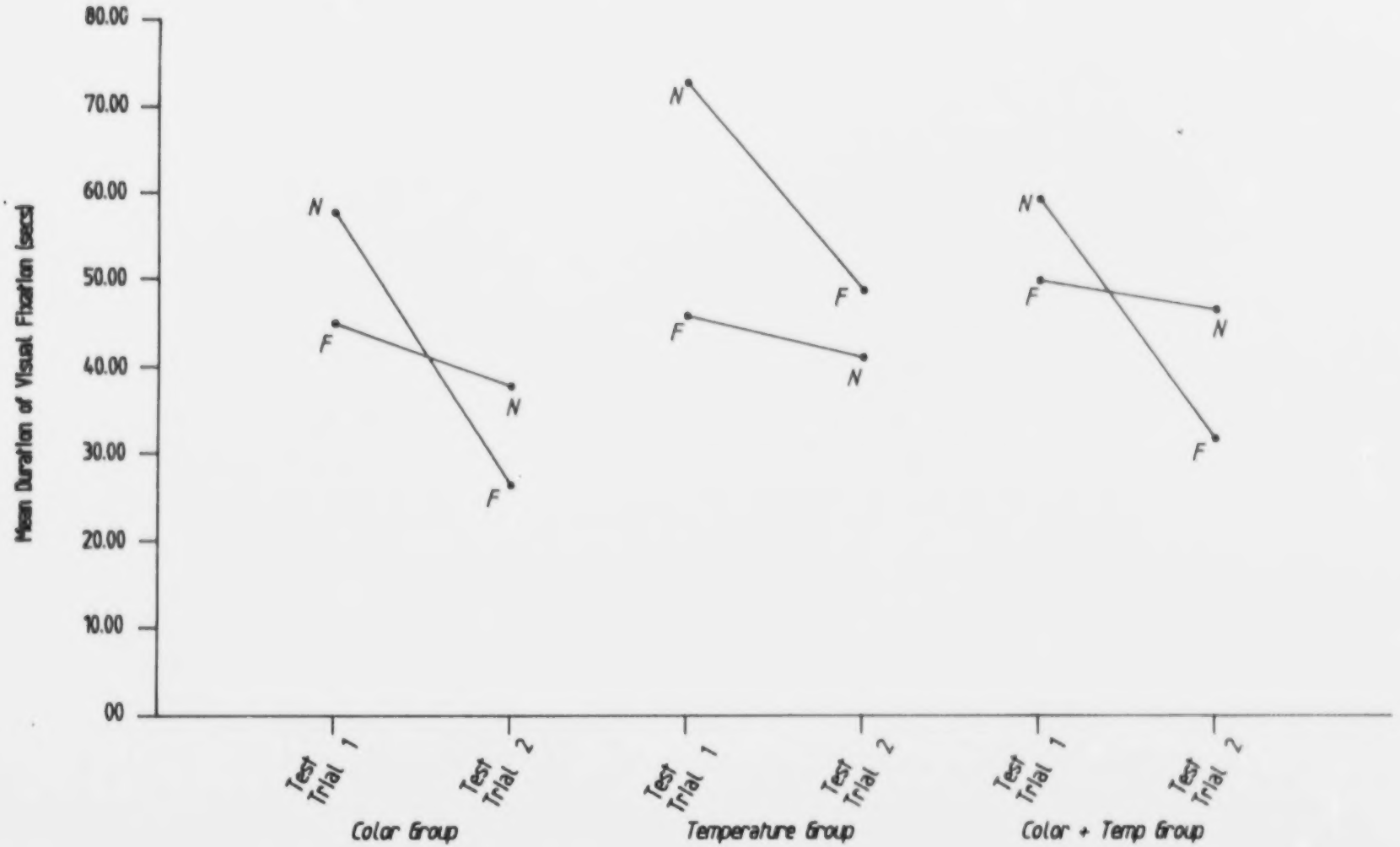
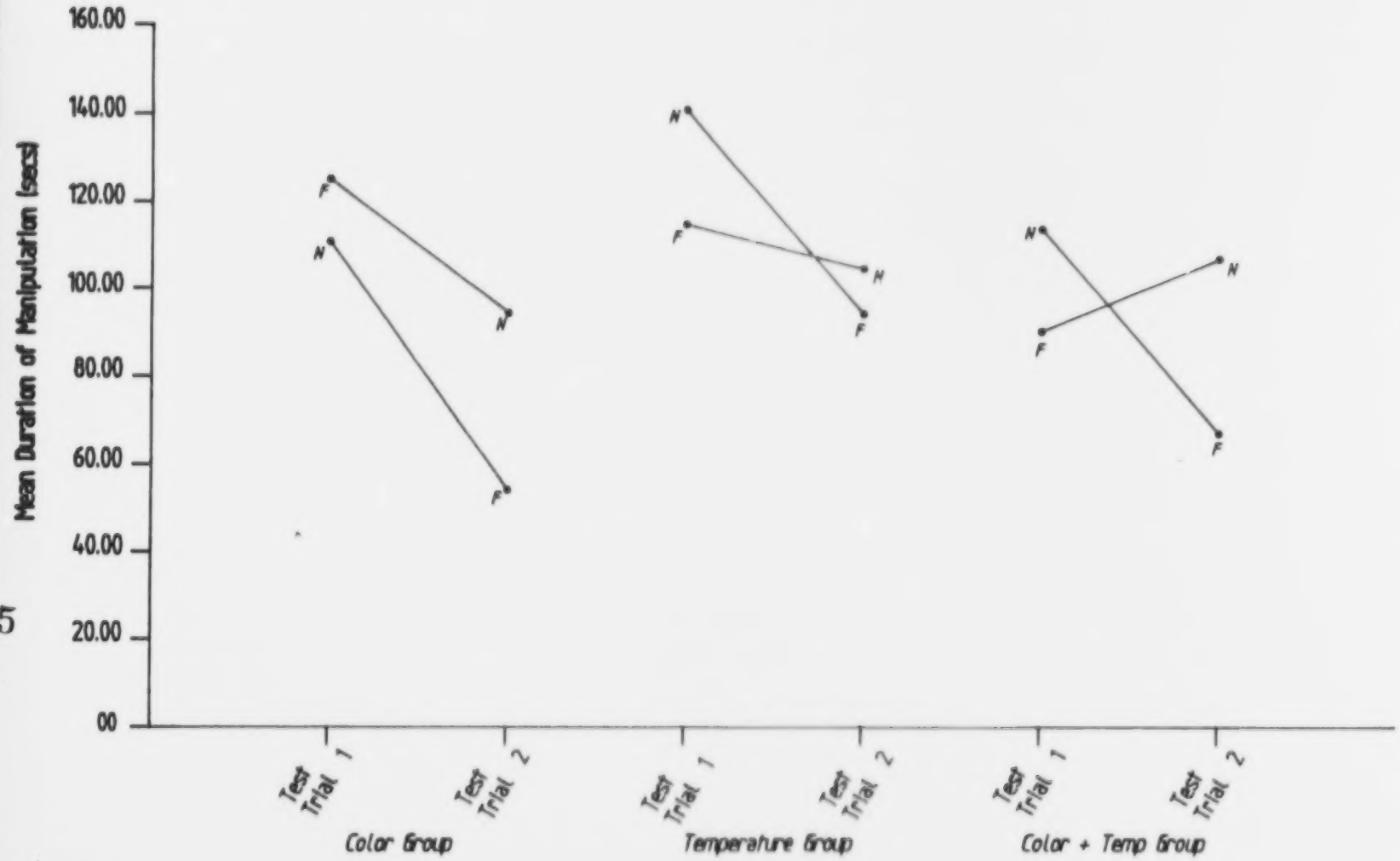


Figure 3. STUDY 1 - ORDER OF TEST TRIALS x TRIALS (N vs F) INTERACTION - MANIPULATION



attention to the novel as compared to the familiar object immediately following the familiarisation trial. Since this would appear to be the stage at which the most vigourous response to novelty could be expected.

In summary, then, the outcomes of Experiment 1 so far discussed are inconclusive in regard to whether infants processed information about the colors and temperatures of objects they explored. Further analyses will be conducted to examine this more fully. However, since there was some suggestion in the data that color and temperature novelty was responded to when the novel object was presented first, we decided to explore in a preliminary way how infants respond when presented with an object which is a novel compound of previously experienced colors and temperatures.

Experiment 2

Eighteen healthy full term infants aged between 27 and 30 weeks participated in Experiment 2 and the procedure was as described for Experiment 1 except that each infant received two familiarisation treials with an object of a different color and temperature being presented in each trial. For example, if an infant was familiarised on the first trial with a WR object the second familiarisation object would be CB. During familiarisation, therefore, infants were presented with each of the two colors and temperatures. Following familiarisation, infants were randomly assigned by sex to either an Experimental or Control group. The groups differed in terms of the objects presented in the two test trials. For Experimental subjects, test trial one consisted of presentation of an object which was a novel compound of the

stimulus characteristics presented during familiarisation. For example if the familiarisation objects were WR and CB, the first test trial object would have been WB or CR. The second test trial for these infants consisted in representation of one of the objects presented during familiarisation. For Control group subjects the presenttion ofthe test trial objects ws reversed i.e. one of the familiar objects was presented on the first test trial and the novel recombination on the second test trial. Counterbalancing was used to ensure that each color and temperature was used equally often across the two groups in each position.

Familiarisation data was analysed using a 2 (Group) x 2 (Color of familiarisation object) x 2 (Temperature of familiarisation object) ANOVA for each familiarisation trial separately. As in Experiment 1, there were no significant outcomes for these analyses and in subsequent analyses the data were combined for the two colors and temperatures.

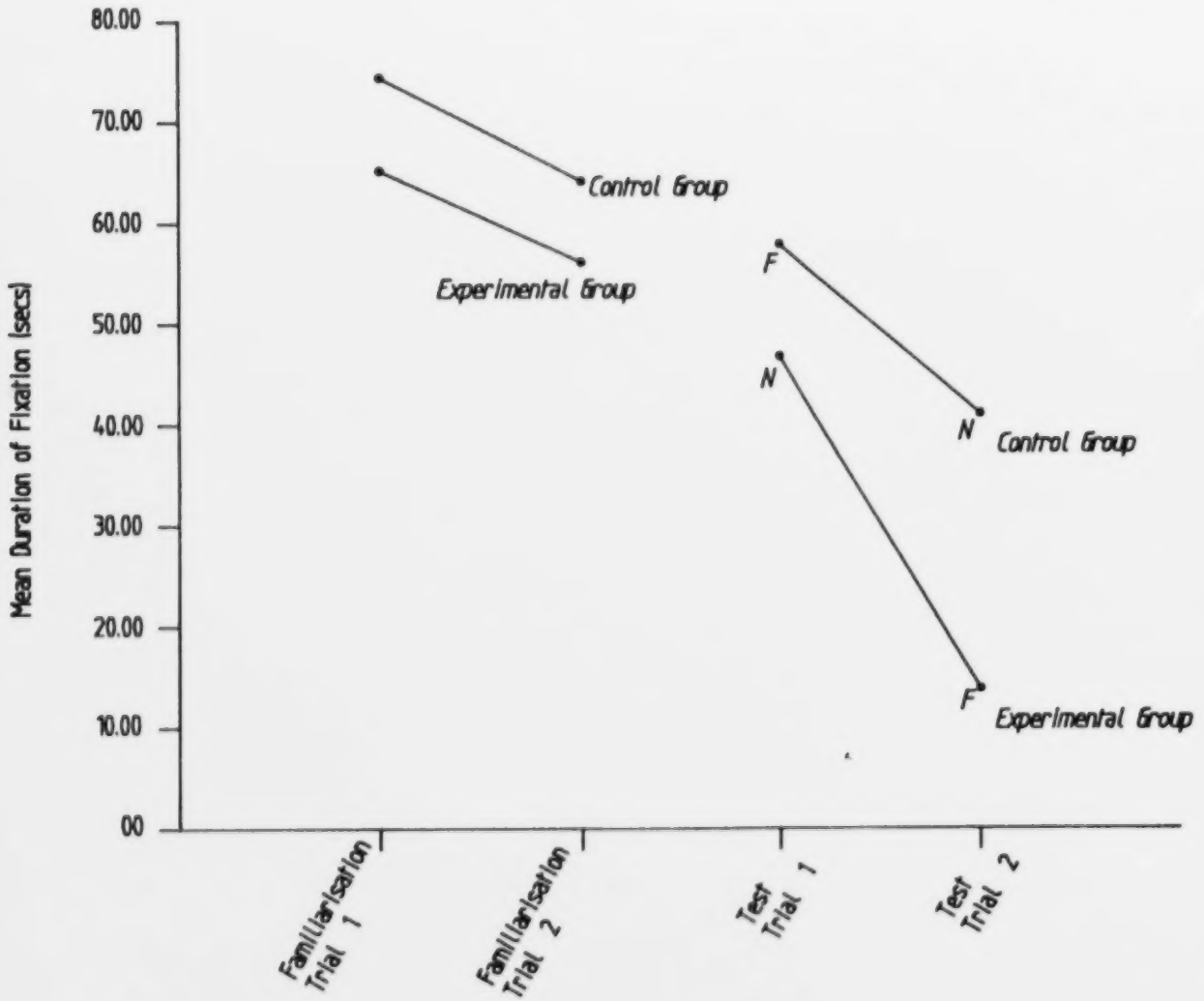
Test trial data were analysed using a 2 (Group) x 2 (Trials 1 vs 2) ANOVA with repeated measures on the second factor.

For duration of fixation data, the main effect of Group and Trials were significant, $F(1,14) = 4.61$, $p=.05$ and $F(1,14) = 9.08$, $P=.009$ respectively. These data are presented in Figure 4.

O/H 5 Figure 4 Visual fixation duration - Study 2.

As shown in Figure 4, infants showed more visual

Figure 4. STUDY 2 DATA - DURATION OF FIXATION



interest on the first test trial than on the second. Furthermore infants in the Control group showed a heightened interest in the test trial objects which was unexpected. This would appear to result mainly from differences between the two groups on the second test trial, but unfortunately, the critical Group x Trials interaction was not significant; $F(1,14) = .95$, $p=.345$.

Duration of manipulation data is presented in Figure 5.

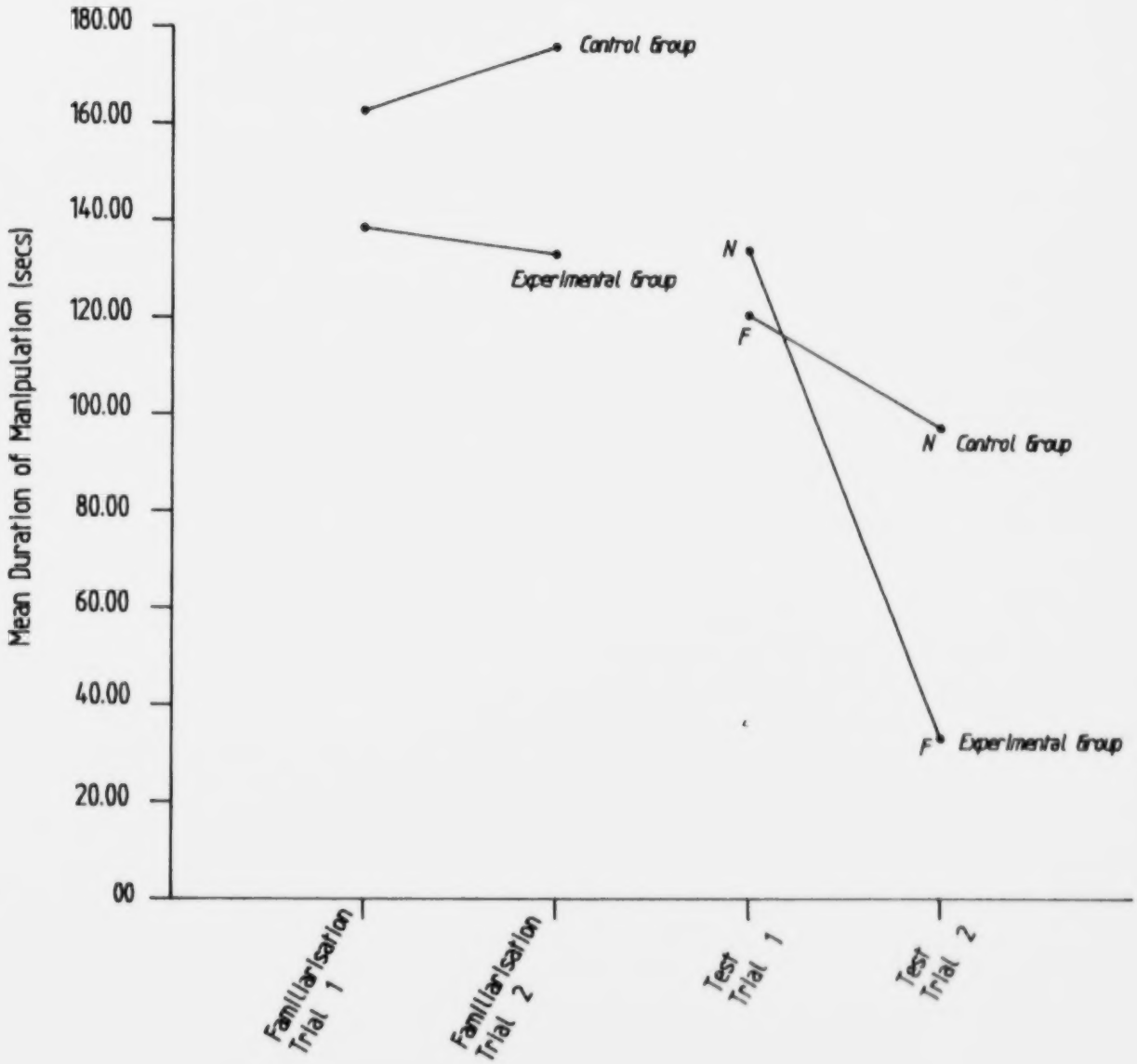
O/H 6 Figure 5 Manipulation duration - Study 2

Although manipulation durations were significantly longer on Test trial 1 than Test trial 2, $F(1,14) = 6.56$, $p=.023$, the Group x Trials interaction again failed to reach significance, $F(1,14) = 2.98$, $p=.107$.

There were no significant effects for length of first fixation data.

To summarise then, at this stage in our data analyses we do not have strong evidence for infant memory of visually and haptically specific object features following bimodal exploration. Whether the reason for this lies in the information processing of these features by infants under these conditions or is simply a reflection of the rather gross behavioural measures we have used is yet to be determined. It could be that when infants interact with objects bimodally, their interest in one object rather than another is not reflected in a measure of response in one modality or another

Figure 5. STUDY 2 DATA - DURATION OF MANIPULATION



but rather in some more subtle combination of the two. Ruff (1986) eg. refers to a behaviour which she calls "examining". This is a rather intense kind of exploratory activity involving concurrent visual and haptic attention which is not the same as the simple sum of the amount of time spent looking and touching. It could be that this measure, or perhaps more likely, the length of the first part of this behaviour may be a more sensitive index of infant responsiveness under bimodal conditions of exploration. It has been argued elsewhere (Rolfe-Zikman, 1987) that "a bimodal learning context may not be the simple sum of the two unimodal contexts of which it is comprised". While these comments were made in relation to information "pick up" it is possible that they apply equally to response output. The challenge perhaps lies in uncovering what those responses are.

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